Multiple isotope geochronology of the Permo-Triassic Araguainha impact crater and implications for the carbon isotope record

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The Permo-Triassic boundary (ca. 252 Ma) marks the largest mass extinction in Earth history, an event accompanied by strong perturbations of the global carbon reservoir. New U-Pb and $^{40}Ar/^{39}Ar$ geochronological data from the largest impact crater in South America, the 40 km diameter Araguainha structure of central Brazil suggest a link to these events. Calculations of the energy released by the impact suggests that the volume of atmospheric ejecta was insufficient to cause the 'nuclear winter' scenario envisioned as a result of the Chicxulub impact, associated with the K-T extinction. However, the Araguainha crater may have been a significant source of isotopically light carbon in sufficient quantities to alter the global carbon cycle. We explore the various mechanisms by which the impact crater may have caused the isotopic shift long noted at the Permo-Triassic boundary.

The Karakoç magmatic association (central Anatolia, Turkey): Intrusive products of H_2O and CO_2 rich alkaline melt

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The Karakoç Magmatic Association (KMA) within Central Anatolian Crystalline Complex (Turkey) consists of ultramafic cumulates, layered gabbros and diorite. The KMA intruded the carbonate dominated upper part of the Complex as a network and includes host rock xenoliths.

The KMA is characterized by abundance of Ca-rich phases, such as diopside, pargasite, plagioclase, scapolite and calcite. Ca-free phlogopite and alkali-feldspar are also present as essential phases. In ultramafic and gabbroic rocks, mafic minerals are cumulate phases. Green diopside (Mg#=57-93) is the first phase. Phlogopite (Mg#=71-76) exits as large or as needle like crystals. Pargasite (Mg#=41-86) occurs as primary prismatic crystals and as pseudomorphs after diopside. Plagioclase, scapolite and calcite, especially in ultramafic and mafic rocks, are post-cumulate phases. Plagioclase (An=91-95) shows polysynthetic twinning. Scapolite (Me=42-92) and calcite (nearly pure) are in textural equilibrium with surrounding silicates, inferring magmatic origin. Alkali-feldspar dominates in diorite. Accessory phases are apatite, sphene, rutile, zircon, and Fe-oxides. Large crystals of apatite and sphene are especially abundant in pargasite rich rocks.

The KMA, with mineral assemblages indicative of high H_2O and CO_2 contents, has SiO_2 ranging from 34.8 to 58.7 wt%. The KMA, rich in CaO, Na_2O and K_2O contents, has high-K alkaline nature. The rocks have positive anomalies of Th, U, K and Pb, and negative anomalies of Nb, Ta, Ti, Zr on the primitive mantle normalized spider diagrams. Depending on presence of apatite, both positive and negative anomalies of P are marked. The KMA is enriched in REE ($\sum$REE=179-673) and display sloped pattern from LREE to HREE.

The field, petrographical and geochemical evidences suggest that the KMA rocks are the products of a hydrous mafic magma derived from a previously enriched mantle by subduction derived components. Moreover, the data manifest significant crustal contribution that is characterized by assimilation of carbonate host rock causing an increase in alkalinity and desilicification of the host magma.

The KMA is strongly comparable with gabbroic units of A-type granitoids generated in a post-collisional extensional setting during the Late Cretaceous in the region. This setting also facilitates the release of CO_2 to result the extensive carbonate assimilation in liquid state.